Appendix E
White Papers to Support Study

RPT-3008859-000

Prepared by: AREVA Federal Services LLC

E.1 STAD Loading Time Study

E.1.1 Purpose

The purpose of this report is to identify the steps and work time required to load UNF into small, medium, and large sized STADs. The study looks at STAD loading at a dry cell-type facility (Dry Loading) and at a reactor site SFP (Wet Loading). The STADs will be loaded in preparation for transfer to storage or for transportation to a CSF geological repository.

E.1.2 Background

At-reactor storage of UNF is necessary in the United States until a program for long-term storage or disposal has been approved and a site has been constructed. Current storage locations include both operating and shutdown reactors. Storage locations also include several reactor sites that have been decommissioned.

Wet storage facilities exist at operating reactor sites in the form of SFPs. Most operating and shutdown sites also have dry storage facilities for storage of UNF. This UNF is typically stored dry in canister-based systems. Dry storage is expected to be in use by all sites, as SFP storage capacities are exceeded.

There are several different designs and capacities of dry storage canisters and those currently in use are not necessarily designed or licensed for transportation from their present locations to a CSF or geological repository. None are licensed to act as containers for use at the final repository. Therefore, DOE is investigating the use of a standardized canister-based dry storage system that can be used to store, age, transport, and dispose of UNF in the final repository.

E.1.3 Industry Experience

At U.S. reactor sites there is considerable experience placing UNF into containers of various types using SFPs. There is currently no broad body of U.S. field experience for loading containers using dry methods. There is experience available from the two lines at the AREVA La Hague, the Rokkasho Reprocessing Plant in Japan, the Thermal Oxide Reprocessing Plant in the UK, and the concept design of the ENSA interim storage facility in Spain.

E.1.4 Scope

This white paper is limited to discussion of loading UNF into STAD canisters for the following cases described in the main body of the AREVA STAD report to DOE:

- Small STAD (Option 3a) – 1 PWR UNF assembly/2 BWR UNF assembly capacity; dry loading
- Medium Capacity STAD (Option 5) – 4 PWR UNF assembly/9 BWR UNF assembly capacity; dry loading
- Large Capacity STAD (Option 7) – 21 PWR UNF assembly/44 BWR UNF assembly capacity; dry loading
- Small STAD (Option 3a) – 1 PWR UNF assembly/2 BWR UNF assembly capacity; wet loading

- Medium Capacity STAD (Option 5) – 4 PWR UNF assembly/9 BWR UNF assembly capacity; wet loading
- Large Capacity STAD (Option 7) – 21 PWR UNF assembly/44 BWR UNF assembly capacity; wet loading

This paper does not address handling of the canisters or their content after loading, i.e. the transfer of the STAD canister to a storage or transportation overpack.

E.1.5 Time Study

Small STAD, Dry

Initial Conditions: UNF will be loaded into Option 3a STADs. For the purposes of this study, it is assumed that BWR fuel will be loaded, 2 assemblies per STAD and 12 STADs per handling frame for a total of 24 assemblies per frame. For this study, it is also assumed that a Part 72 canister has been opened, i.e. welds for both lids have been cut and it is ready for transfer of fuel to the STADs.

Transfer of fuel will occur in a purpose built dry cell. Preparation of the loaded STADs for storage or transportation will occur in a purpose built preparation area that may or may not be integrated into the hot cell. All activities are continuous and will be performed on a 2-shift, 24-hour day basis (see Table E.1-1).

The following equipment is staged in the STAD preparation area and is available for use: welding machine, remote NDE device, helium fill device, and helium detection device. This equipment will be indexed to the STADs such that it can be placed, used, and removed remotely. The helium purge and fill and the helium leak test will be performed on 3 STADs simultaneously.

The following steps will be used for STAD loading and preparation for either transport or storage:

- Prepare STAD for loading:
  - Clean STADs (12x) and handling frame.
  - Place STADs into frame (12x).
  - Place loaded frame into transfer cask.
  - Move transfer cask into hot cell.
- Stage STAD lids and port covers in hot cell and prep area (12x).
- Transfer loaded Part 72 canister to hot cell.
- Transfer UNF from Part 72 canister to STADs (24x).
- Place inner lids on STADs (12x).
- Move loaded STADs in handling frame/transfer cask to preparation area.
- Move empty Part 72 canister to decontamination area.

- Place remote welding machine on inner lid of first STAD to be welded.
- Perform first STAD inner lid root pass weld.
- Move welding machine to next STAD and repeat Steps 8 and 9 for remaining STADs (11x).
- Perform remote NDE of inner lid root pass weld (12x).
- Weld first STAD inner lid final pass.
- Weld remaining STAD inner lid final pass (11x).
- Perform remote NDE of inner lid final pass weld (12x).
- Perform helium purge and fill (3 x 4).
- Attach helium supply and vent lines to inner lid quick connects.
- Flow helium through STAD for required time.
- Disconnect vent line.
- Fill STAD with helium to prescribed pressure.
- Disconnect fill line.
- Place, weld in place, and perform NDE for inner lid port covers.
- Place outer lids on STADs (12x).
- Place remote welding machine on outer lid of first STAD to be welded (root pass).
- Perform first STAD outer lid root pass weld.
- Move welding machine to next STAD and repeat Steps 17 and 18 for remaining STADs (11x).
- Perform remote NDE of outer lid root pass weld (12x).
- Place remote welding machine on outer lid of first STAD to be welded (final pass).
- Perform first STAD outer lid root final weld.
- Move welding machine to next STAD and repeat Steps 20 and 21 for remaining STADs (11x).
- Perform remote NDE of outer lid final pass weld (12x).
- Perform helium leak test (3 x 4).
- Seal weld/NDE outer lid port cover.
- Install handling frame cover (bolt in place).
- Install transfer/transportation cask lid.
- Move cask for transfer to storage cask or preparation for transport.

Table E.1-1. Small STAD Loading Time and Sequence, Dry

Step	Description	Pre-decessor(s)	Time Req'd (Hours)	Re-peat	Total Time Req'd (Hrs)		Elapsed Time (Hrs)
1	Prepare STADs		6	1	6	Day 1	
2	Stage lids and port covers		2	1	2		
3	Transfer Part 72 canister to hot cell	1	2	1	2		8
4	Transfer UNF	2, 3	0.5	24	12		
5	Place STAD inner lids	2, 4	0.25	12	3		
6	Move STADs to prep area	5	1	1	1		24
7	Move empty Part 72 canister	6	2	1	2		24
8	Place welding machine on first STAD	6	0.5	1	0.5	Day 2	
9	Weld first STAD inner lid root weld	8	1	1	1		
10	Weld remaining STADs	9	1.5	11	16.5		42
11	NDE of inner lid root weld	10	1	12	12	Day 3	
12	Weld first STAD inner lid final pass	11	1.5	1	1.5		
13	Weld remaining STADs inner lid final pass	12	1.5	12	18	Day 4	73.5
14	NDE of inner lid final pass	13	1	12	12		
15	Helium purge and fill	14	2	4	8		
16	Place outer lids	14	0.5	12	6	Day 5	99.5
17	Place welding machine on first STAD	15	0.5	1	0.5		
18	Weld first STAD outer lid root	16	1	1	1		
19	Weld remaining STADs	17	1.5	11	16.5		117.5
20	NDE of outer lid root weld	18	1	12	12	Day 6	
21	Place welding machine on first STAD	19	0.5	1	0.5		
22	Weld first STAD outer lid final pass	20	1	1	1		131
23	Weld remaining STADs outer lid final pass	21	1.5	11	16.5	Day 7	

Step	Description	Pre-decessor(s)	Time Req'd (Hours)	Re-peat	Total Time Req'd (Hrs)		Elapsed Time (Hrs)
24	NDE of outer lid final pass	22	1	12	12		
25	Perform helium leak test	23	2	4	8		167.5
26	Seal weld/NDE outer lid port cover	24	1	12	12	Day 8	
27	Install handling frame outer cover (bolt in place)	23	2	1	2		
28	Install transfer/transportation cask lid	24	2	1	2		183.5
29	Move cask for transfer to storage or transportation						

Medium STAD, Dry

Initial Conditions: UNF will be loaded into Option 5 STADs. For the purpose of this study, it is assumed that BWR fuel will be loaded 9 assemblies per STAD and 3 STADs per handling frame for a total of 27 assemblies per frame. All other initial conditions are the same as for the small STAD (see Table E.1-2).

The following steps will be used for STAD loading and preparation for either transport or storage:

- Prepare STADs for loading:
  - Clean STADs (3x) and handling frame.
  - Place STADs into frame (3x).
  - Place loaded frame into transfer cask.
  - Move transfer cask into hot cell.
- Stage STAD inner lids in hot cell (3x).
- Transfer loaded Part 72 canister to hot cell.
- Transfer UNF from Part 72 canister to STADs (27x).
- Place inner lids on STADs (3x).
- Move loaded STADs in handling frame/transfer cask to preparation area.
- Move empty Part 72 canister to decontamination area.
- Place remote welding machine on inner lid of first STAD to be welded.
- Perform first STAD inner lid root pass weld.
- Move welding machine to next STAD and repeat Steps 8 and 9 for remaining STADs (2x).

- Perform remote NDE of inner lid root pass weld (3x).
- Weld first STAD inner lid final pass.
- Weld remaining STAD inner lid final pass (2x).
- Perform remote NDE of inner lid final pass weld (3x).
- Perform helium purge and fill (3 x 1).
- Attach helium supply and vent lines to inner lid quick connects.
- Flow helium through STAD for required time.
- Disconnect vent line.
- Fill STAD with helium to prescribed pressure.
- Disconnect fill line.
- Place, weld in place, and perform NDE for inner lid port covers.
- Place outer lids on STADs (3x).
- Place remote welding machine on outer lid of first STAD to be welded (root pass).
- Perform first STAD outer lid root pass weld.
- Move welding machine to next STAD and repeat Steps 17 and 18 for remaining STADs (2x).
- Perform remote NDE of outer lid root pass weld (3x).
- Place remote welding machine on outer lid of first STAD to be welded (final pass).
- Perform first STAD outer lid root final weld.
- Move welding machine to next STAD and repeat Steps 21 and 22 for remaining STADs (2x).
- Perform remote NDE of outer lid final pass weld (3x).
- Perform helium leak test (3 x 1).
- Seal weld/NDE outer lid port cover (3x).
- Install handling frame cover (bolt in place).
- Install transfer/transportation cask lid.
- Move cask for transfer to storage cask or preparation for transport.

Table E.1-2. Medium STAD Loading Time and Sequence, Dry

Step	Description	Predecessor(s)	Time Required (Hours)	Re-peat	Total Time Req'd (Hours)		Elapsed Time (Hours)
1	Prepare STADs		6	1	6	Day 1	
2	Stage inner lids		2	1	2		
3	Transfer Part 72 Canister to hot cell	1	2	1	2		8
4	Transfer UNF	2, 3	0.5	27	13.5		
5	Place STAD inner lids	2, 4	0.5	3	1.5		
6	Move STADs to prep area	5	1	1	1		24
7	Move empty Part 72 canister	6	2	1	2	Day 2	
8	Place welding machine on first STAD	6	0.5	1	0.5		
9	Weld first STAD inner lid root weld	8	1.25	1	1.25		25.75
10	Weld remaining STADs	9	1.75	2	3.5		
11	NDE of root weld	10	1	3	3		
12	Weld first STAD inner lid final pass	11	1.75	1	1.75		34
13	Weld remaining STADs inner lid final pass	12	1.75	2	3.5		
14	NDE of inner lid final pass	13	1	3	3		
15	Helium purge and fill	14	4	3	12	Day 3	52.5
16	Place outer lids	14	0.5	3	1.5		
17	Place welding machine on first STAD	15	0.5	1	0.5		
18	Weld first STAD outer lid root	16	1.25	1	1.25		55.75
19	Weld remaining STADs	17	1.75	3	5.25		
20	NDE of outer lid root weld	18	1	3	3		
21	Place welding machine on first STAD	19	0.5	1	0.5		64.5
22	Weld first STAD outer lid final pass	20	1.25	1	1.25		
23	Weld remaining STADs outer lid final pass	21	1.75	2	3.5		
24	NDE of outer lid final pass	22	1	3	3	Day 4	71.5
25	Perform helium leak test	23	2.5	3	7.5		
26	Seal weld/NDE outer lid port cover	24	1	3	3		

Step	Description	Predecessor(s)	Time Required (Hours)	Re-peat	Total Time Req'd (Hours)		Elapsed Time (Hours)
27	Install handling frame outer cover (bolt in place)	23	2	1	2		
28	Install transfer/transportation cask lid	24	2	1	2		86.75
29	Move cask for transfer to storage or transportation						

Large STAD, Dry

Initial Conditions: UNF will be loaded into Option 7 STADs. For the purpose of this study, it is assumed that BWR fuel will be loaded 44 assemblies per STAD. For this study, it is also assumed that a Part 72 canister has been opened, i.e. welds for both lids have been cut and it is ready for transfer of its fuel to the STADs (see Table E.1-3).

Transfer of fuel will occur in a purpose built dry cell. Other initial conditions are the same as assumed for the small and medium STADs.

The large STAD will be loaded in the same manner as a Part 72 dual-purpose canister. The loading sequence below is derived from a typical Part 72 canister sequence. Note that since these operations are performed in a dry cell, draining and vacuum drying activities are not required.

- Prepare STAD for loading:
  - Clean STAD.
  - Place STAD into transfer cask.
  - Move transfer cask into hot cell.
- Stage STAD inner and outer lids in hot cell.
- Transfer loaded Part 72 canister to hot cell.
- Transfer UNF from Part 72 canister to STAD (44x).
- Place inner lid on STAD.
- Move loaded STAD in transfer cask to preparation area.
- Move empty Part 72 canister to decontamination area.
- Weld and NDE inner top lid.
- Perform inner lid root pass weld.
- Perform remote NDE of inner lid root pass weld.
- Weld inner lid final pass.
- Perform remote NDE of inner lid final pass weld.
- Perform helium purge and fill.

- Attach helium supply and vent lines to inner lid quick connects.
- Flow helium through STAD for required time.
- Disconnect vent line.
- Fill STAD with helium to prescribed pressure.
- Disconnect fill line.
- Weld and NDE outer top lid.
- Perform outer lid root pass weld.
- Perform remote NDE of outer lid root pass weld.
- Weld outer lid final pass.
- Perform remote NDE of outer lid final pass weld.
- Perform helium leak test.
- Seal weld/NDE outer lid port cover.
- Install transfer cask lid.
- Move cask for transfer to storage or transport cask.

Table E.1-3. Large STAD Loading Time and Sequence, Dry

Step	Description	Predecessor (s)	Time Req'd (Hours)	Re-peat	Total Time Req'd (Hrs)		Elapsed Time (Hrs)
1	Prepare STAD		6	1	6	Day 1	
2	Stage lids		2	1	2		
3	Transfer Part 72 Canister to hot cell	1	2	1	2		8
4	Transfer UNF	2, 3	0.25	44	11		
5	Place STAD inner lid	2, 4	1	1	1		
6	Move STAD to prep area	5	4	1	4		24
7	Move empty Part 72 canister	6	2	1	2		
8	Weld and NDE inner top lid	6	13	1	13	Day 2	
9	Perform helium purge and fill	8	6	1	6		43
10	Weld and NDE outer top lid	9	8	1	8	Day 3	
11	Helium leak test	11	2	1	2		
12	Seal weld/NDE outer lid port cover	12	2	1	2		55
13	Install transfer/transportation cask lid	13	2	1	2		57
14	Move cask for transfer to storage or transportation						

Small STAD, Wet

Initial Conditions: UNF will be loaded into Option 3a STADs. For the purpose of this study, it is assumed that BWR fuel will be loaded 2 assemblies per STAD and 12 STADs per handling frame for a total of 24 assemblies per frame (see Table E.1-4).

Transfer of fuel will occur in a wet pool. This study assumes that the wet pool is a pool used for storage of UNF at a reactor site. For study purposes, the canister/STAD could be located either directly in the SFP or in a cask-loading pit that is connected to the pool and flooded. Preparation of the loaded STADs for storage or transportation will occur in a dry preparation area located adjacent to the SFP. All STAD loading and preparation activities are performed continuously on a 2-shift, 24 hours-per-day basis.

For this study, it is also assumed that a Part 72 canister has been opened, i.e. welds for both lids have been cut and it is ready for transfer of fuel to the STADs, has been staged in the reactor site Fuel Building and is ready to be placed in the site SFP.

The following equipment is staged in the STAD preparation area and is available for use: welding machine, remote NDE device, vacuum drying equipment, helium purge, fill equipment,

and helium detection device. The helium purge and fill, and the helium leak test will be performed on three STADs simultaneously.

The following steps will be used for STAD loading and preparation for either transport or storage:

- Prepare STAD for loading:
  - Clean STADs (12x) and handling frame.
  - Place STADs into frame (12x).
  - Place loaded frame into transfer cask.
- Assumes two transfer casks are available simultaneously: one for STADs and one for the opened Part 72 canister.
- Move into Fuel Building.
- Stage STAD lids and port covers in prep area (12x).
- Move transfer cask with loaded Part 72 canister into SFP.
- Transfer UNF from Part 72 canister into temporary storage rack.
- Remove transfer cask with empty Part 72 canister from SFP and move to preparation area.
- Drain canister and transfer cask and prepare for decon.
- Prepare STADs and transfer cask for transfer to SFP.
- Transfer cask and STADs to SFP.
- Transfer UNF from temporary racks to STADs (24x).
- Place inner lids on STADs (12x).
- Move loaded STADs in handling frame/transfer cask to preparation area.
- Perform drain downs and inner lid weld preps (12x).
- Place remote welding machine on inner lid of first STAD to be welded.
- Perform first STAD inner lid root pass weld.
- Move welding machine to next STAD and repeat Steps 8 and 9 for remaining STADs (11x).
- Perform remote NDE of inner lid root pass weld (12x).
- Weld first STAD inner lid final pass.
- Weld remaining STAD inner lid final pass (11x).
- Perform remote NDE of inner lid final pass weld (12x).
- Perform vacuum drying and helium fill (3 x 4).

- Place, weld in place, and perform NDE for inner lid port covers (2 x 12).
- Place outer lids on STADs (12x).
- Place remote welding machine on outer lid of first STAD to be welded (root pass).
- Perform first STAD outer lid root pass weld.
- Move welding machine to next STAD and repeat Steps 23 and 24 for remaining STADs (11x).
- Perform remote NDE of outer lid root pass weld (12x).
- Place remote welding machine on outer lid of first STAD to be welded (final pass).
- Perform first STAD outer lid root final weld.
- Move welding machine to next STAD and repeat Steps 27 and 28 for remaining STADs (11x).
- Perform remote NDE of outer lid final pass weld (12x).
- Perform helium leak test (3 x 4).
- Seal weld/NDE outer lid port cover (12x).
- Prepare handling frame for transfer and install handling frame cover (bolt in place).
- Prepare transfer cask for movement and install cask lid.
- Move cask for transfer to storage cask or transport cask.

Table E.1-4. Small STAD Loading Time and Sequence, Wet

Step	Description	Predecessor(s)	Time Req'd (Hrs)	Re-peat	Total Time Req'd (Hrs)		Elapsed Time
1	Prepare STADs		6	1	6	Day 1	
2	Stage lids and port covers in FB		2	1	2		
3	Move Part 72 Canister to SFP	1	3	1	3		8
4	Transfer UNF from Part 72 can to temp. rack	2, 3	0.25	24	6		
5	Remove Part 72 canister from SFP		4	1	4		
6	Drain canister & transfer cask, decon		6	1	6		24
7	Prepare STADs & cask for move to SFP		2	1	2	Day 2	
8	Move STADs to SFP		3	1	3		
9	Transfer UNF from rack to STADs		0.25	24	6		35
10	Place inner lids on STADs		0.25	12	3		
11	Move STADs to prep area		2	1	2		
12	Perform drain downs & weld preps		0.5	12	6		46
13	Place welding machine on first STAD	6	0.5	1	0.5		
14	Weld first STAD inner lid root weld	8	1	1	1		
15	Weld remaining STADs	9	1.5	11	16.5	Day 3	64
16	NDE of inner lid root weld	10	1	12	12	Day4	
17	Weld first STAD inner lid final pass	11	1.5	1	1.5		
18	Weld remaining STADs Inner Lid Final Pass	12	1.5	12	18		95.5
19	NDE of inner lid final pass	13	1	12	12	Day 5	
20	Vacuum drying and helium fill	14	6	4	24	Day 6	
21	Place, weld, NDE inner port covers		0.5	24	12		143.5
22	Place outer lids	14	0.5	12	6	Day 7	
23	Place welding machine on first STAD	15	0.5	1	0.5		
24	Weld first STAD outer lid root	16	1	1	1		151

Step	Description	Predecessor(s)	Time Req'd (Hrs)	Re-peat	Total Time Req'd (Hrs)		Elapsed Time
25	Weld remaining STADs	17	1.5	11	16.5		
26	NDE of outer lid root weld	18	1	12	12	Day 8	
27	Place welding machine on first STAD	19	0.5	1	0.5		180
28	Weld first STAD outer lid final pass	20	1	1	1		
29	Weld remaining STADs outer lid final pass	21	1.5	11	16.5	Day 9	
30	NDE of outer lid final pass	22	1	12	12		209.5
31	Perform helium leak test	23	2	4	8	Day 10	
32	Seal weld/NDE outer lid port cover	24	1	12	12		
33	Prepare handling frame for transfer	23	2	1	2		231.5
34	Prepare transfer cask for transfer	24	2	1	2		233.5
35	Move cask for transfer to storage or transportation						

Medium STAD, Wet

Initial Conditions: UNF will be loaded into Option 5 STADs. For the purpose of this study, it is assumed that BWR fuel will be loaded 9 assemblies per STAD and 3 STADs per handling frame for a total of 27 assemblies per frame. All other initial conditions are the same as for a small STAD, wet (see Table E.1-5).

The following steps will be used for STAD loading and preparation for either transport or storage:

- Prepare STAD for loading:
  - Clean STADs (3x) and handling frame.
  - Place STADs into frame (3x).
  - Place loaded frame into transfer cask.
- Assumes two transfer casks are available simultaneously: one for STADs and one for the opened Part 72 canister.
- Move into Fuel Building.
- Stage STAD lids and port covers in prep area (3x).
- Move transfer cask with loaded Part 72 canister into SFP.
- Transfer UNF from Part 72 canister into temporary storage rack.

- Remove transfer cask with empty Part 72 canister from SFP and move to preparation area.
- Drain canister and transfer cask and prepare for decon.
- Prepare STADs and transfer cask for transfer to SFP.
- Transfer cask and STADs to SFP.
- Transfer UNF from temporary racks to STADs (27x).
- Place inner lids on STADs (3x).
- Move loaded STADs in handling frame/transfer cask to preparation area.
- Perform drain downs and inner lid weld preps (3x).
- Place remote welding machine on inner lid of first STAD to be welded.
- Perform first STAD inner lid root pass weld.
- Move welding machine to next STAD and repeat Steps 13 and 14 for remaining STADs (2x).
- Perform remote NDE of inner lid root pass weld (3x).
- Weld first STAD inner lid final pass.
- Weld remaining STAD inner lid final pass (2x).
- Perform remote NDE of inner lid final pass weld (3x).
- Perform vacuum drying and helium fill (3x).
- Place, weld in place, and perform NDE for inner lid port covers (2 x 3).
- Place outer lids on STADs (3x).
- Place remote welding machine on outer lid of first STAD to be welded (root pass).
- Perform first STAD outer lid root pass weld.
- Move welding machine to next STAD and repeat Steps 23 and 24 for remaining STADs (2x).
- Perform remote NDE of outer lid root pass weld (3x).
- Place remote welding machine on outer lid of first STAD to be welded (final pass).
- Perform first STAD outer lid root final weld.
- Move welding machine to next STAD and repeat Steps 27 and 28 for remaining STADs (2x).
- Perform remote NDE of outer lid final pass weld (3x).
- Perform helium leak test (3x).
- Seal weld/NDE outer lid port cover (3x).

- Prepare handling frame for transfer and install handling frame cover (bolt in place).
- Prepare transfer cask for movement and install cask lid.
- Move cask for transfer to storage cask or transport cask.

Table E.1-5. Medium STAD Loading Time and Sequence, Wet

Step	Description	Predecessor(s)	Time Req'd (Hrs)	Re-peat	Total Time Req'd (Hrs)		Elapsed Time (Hrs)
1	Prepare STADs		6	1	6	Day 1	
2	Stage lids and port covers in FB		2	1	2		
3	Move Part 72 Canister to SFP	1	3	1	3		8
4	Transfer UNF from Part 72 can to temp. rack	2, 3	0.25	27	6		
5	Remove Part 72 canister from SFP		4	1	4		
6	Drain canister & transfer cask, decon		6	1	6		24
7	Prepare STADs & cask for move to SFP		2	1	2	Day 2	
8	Move STADs to SFP		3	1	3		
9	Transfer UNF from rack to STADs		0.25	27	6.75		35.75
10	Place inner lids on STADs		0.5	3	1.5		
11	Move STADs to prep area		2	1	2		
12	Perform drain downs & weld preps		1	3	3		42.25
13	Place welding machine on first STAD	6	0.75	1	0.75		
14	Weld first STAD inner lid root weld	8	1.25	1	1.25		
15	Weld remaining STADs	9	2	2	4	Day 3	48.25
16	NDE of inner lid root weld	10	1.5	3	4.5		
17	Weld first STAD inner lid final pass	11	2	1	2		
18	Weld remaining STADs Inner Lid Final Pass	12	2	2	4		58.75
19	NDE of inner lid final pass	13	1.5	3	4.5		
20	Vacuum drying and helium fill	14	6	3	18	Day 4	
21	Place, weld, NDE inner port covers		0.5	6	3		84.25
22	Place outer lids	14	0.5	3	1.5		
23	Place welding machine on first STAD	15	0.75	1	0.75		

Step	Description	Predecessor(s)	Time Req'd (Hrs)	Re-peat	Total Time Req'd (Hrs)		Elapsed Time (Hrs)
24	Weld first STAD outer lid root	16	1.25	1	1.25		87.75
25	Weld remaining STADs	17	2	2	4		
26	NDE of outer lid root weld	18	1.5	3	4.5		
27	Place welding machine on first STAD	19	0.75	1	0.75	Day 5	97
28	Weld first STAD outer lid final pass	20	1.25	1	1.25		
29	Weld remaining STADs outer lid final pass	21	2	2	4		
30	NDE of outer lid final pass	22	1.5	3	4.5		106.75
31	Perform helium leak test	23	2	3	6		
32	Seal weld/NDE outer lid port cover	24	1	3	3		
33	Prepare handling frame for transfer	23	2	1	2		117.75
34	Prepare transfer cask for transfer	24	2	1	2		119.75
35	Move cask for transfer to storage or transportation						

Large STAD, Wet

Initial Conditions: UNF will be loaded into Option 7 STADs. For the purpose of this study, it is assumed that BWR fuel will be loaded 44 assemblies per STAD. For this study, it is also assumed that a Part 72 canister has been opened, i.e. welds for both lids have been cut and it is ready for transfer of fuel to the STADs. Initial conditions are the same as assumed for the small and medium STADs (see Table E.1-6).

The large STAD will be loaded in the same manner as a Part 72 dual-purpose canister. The loading sequence and times below are derived from a typical Part 72 canister sequence.

Table E.1-6. Large STAD Loading Time and Sequence, Wet

Step	Description	Predecessor(s)	Time Req'd (Hrs)	Re-peat	Total Time Req'd (Hrs)		Elapsed Time
1	Prepare STADs		6	1	6	Day 1	
2	Stage lids and port covers in FB		2	1	2		
3	Move Part 72 Canister to SFP	1	3	1	3		8
4	Transfer UNF from Part 72 can to temp. rack	2, 3	0.25	24	6		
5	Remove Part 72 canister from SFP		4	1	4		
6	Drain canister & transfer cask, decon		6	1	6		24
7	Prepare STADs & cask for move to SFP		2	1	2	Day 2	
8	Move STADs to SFP		3	1	3		
9	Transfer UNF	2, 3	0.25	44	11		40
10	Place STAD inner lid	2, 4	1	1	1		
11	Move STAD to prep area	5	4	1	4		
12	Weld and NDE inner top lid	6	13	1	13		58
13	Vacuum drying and helium fill	14	12	1	12		
14	Weld and NDE outer top lid	9	10	1	10	Day 4	
15	Helium leak test	11	2	1	2		82
16	Seal weld/NDE outer lid port cover	12	2	1	2		
17	Install transfer/transportation cask lid	13	2	1	2		86
18	Move cask for transfer to storage or transportation						

E.1.6 Loading Time Comparison

This section provides a comparison between the loading times for the various STADs, as provided previously, with the loading time for a 32 PWR assembly/61 BWR assembly Part 72-licensed DCSS.

Our comparison starts with preparation of the STAD/Part 72 DCSS and ends with the STAD/Part 72 DCSS ready for storage or transportation. For wet loading of STADs, the time does not include the activities for placing and removing the cut open Part 72 canister in the pool and for moving the fuel from the canister to the temporary rack (see Table E.1-7).

Table E.1-7. Loading Time Comparison

Configuration	Wet/Dry	Loading Time			Reference/Notes
		Days	Hours	Hours Per Assembly	
Small STAD (1 PWR/2 BWR)	Dry	8	183.5	7.6	Table 5-1; Load 12 STADs w/24 BWR assemblies simultaneously
Small STAD (1 PWR/2 BWR)	Wet	10	203.5	8.5	Table 5-4; Load 12 STADs w/24 BWR assemblies simultaneously
Medium STAD (4 PWR/9 BWR)	Dry	4	86.75	3.2	Table 5-2; Load 3 STADs w/27 BWR assemblies simultaneously
Medium STAD (4 PWR/9 BWR)	Wet	5	109.75	4.1	Table 5-5; Load 3 STADs w/27 BWR assemblies simultaneously
Large STAD (21 PWR/44 BWR)	Dry	3	57	1.3	Table 5-3; Load 1 STAD w/44 BWR assemblies
Large STAD (21 PWR/44 BWR)	Wet	4	70	1.6	Table 5-3; Load 1 STAD w/44 BWR assemblies
Part 72 DCSS (32 PWR/61 BWR)	Wet	4	74	1.2	Load 61 BWR assemblies

E.1.7 Conclusions

The following conclusions can be reached from examination of Table E.1-7. The first is that if only one canister system is processed through the preparation, loading, sealing, and drying process, then the higher the capacity the container (STAD or Part 72), the more efficient the process, as measured by the hours to load per assembly.

The second conclusion is that dry loading in general requires less time than wet loading. This is a result of two principal factors:

1. There is no need to drain and vacuum dry the canister/UNF.
2. There is no need to decontaminate the canister and/or transfer cask.

The second conclusion is consistent with data from AREVA's La Hague UNF recycling facility. La Hague operations for unloading UNF from transport casks and placing it in wet storage for later recycling consistently show that unloading performed dry (in a hot cell type facility) requires less time than similar operations performed wet. Additionally, fewer dry operations which results in reduced operator hours are needed. The reduced time and operator hours lower the total personnel dose compared to wet operations.

E.2 Mobile Hot Cell Study

The AREVA Team has prepared this white paper to discuss in detail the options for opening and loading UNF from the current large designs of storage canisters in use at U.S. utilities into smaller STADs suitable for transportation and disposal in a geological repository. The work is based on previous dry transfer design concepts carried out for the DOE, as well as industry developments that have occurred over the last 20 years. The study considers several options from modular system to fixed facility, site-specific designs, and a regional approach to the challenges of UNF management.

E.2.1 Modular Systems

Modular systems have been extensively used in the nuclear industry to construct and operate facilities to complete missions with a relatively short mission life. These modular facilities are delivered to a site in standard shipping containers and assembled on site as shown in Figure E.2-1 below.

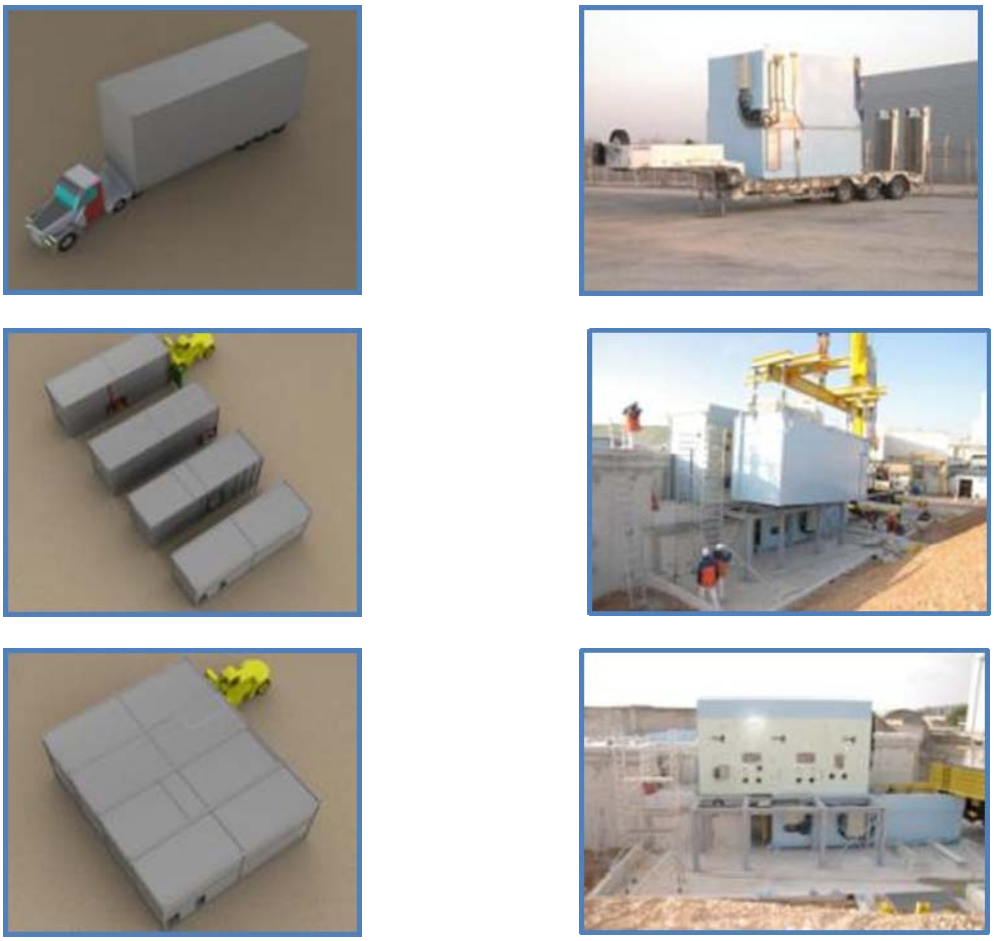

Figure E.2-1. Modular Treatment Facility Design in Standard Shipping Containers and Assembled at Site

E.2.1.1 Transfer Facility Conceptual Description

A mobile hot cell (MHC) is a variation on the dry transfer concept described previously and the modular shipping container. It offers an alternative way of loading STADs at reactor sites without interfering with operations at the UNF pool. The MHC could be deployed at selected sites where fuel from nearby reactors can be transported, thus reducing the total number of required facilities. The sites, or transfer centers, could be selected either on the basis of state boundaries (in states where numerous utilities and reactors are located), or on a regional basis, such as the four NRC regions.

For transfer center siting based on state boundaries, a single reactor would likely be chosen to perform the transfers for all other reactors in that state. Advantages of this option include shorter distances for transporting fuel from reactors to the transfer center and no need to cross state lines. The utility hosting the facility could develop a business plan to be paid for the reloading of the DSCs into STADs.

For transfer center siting based on regional boundaries, approximately one transfer center is needed for each region. The advantages of this option include: fewer transfer centers are needed and more elaborate transfer facilities are economically feasible. Figure E.2-2 provides the locations of reactor sites in the U.S. and Figure E.2-3 shows the boundaries of NRC regions.

Figure E.2-2. Operating Reactors in the U.S., 2013

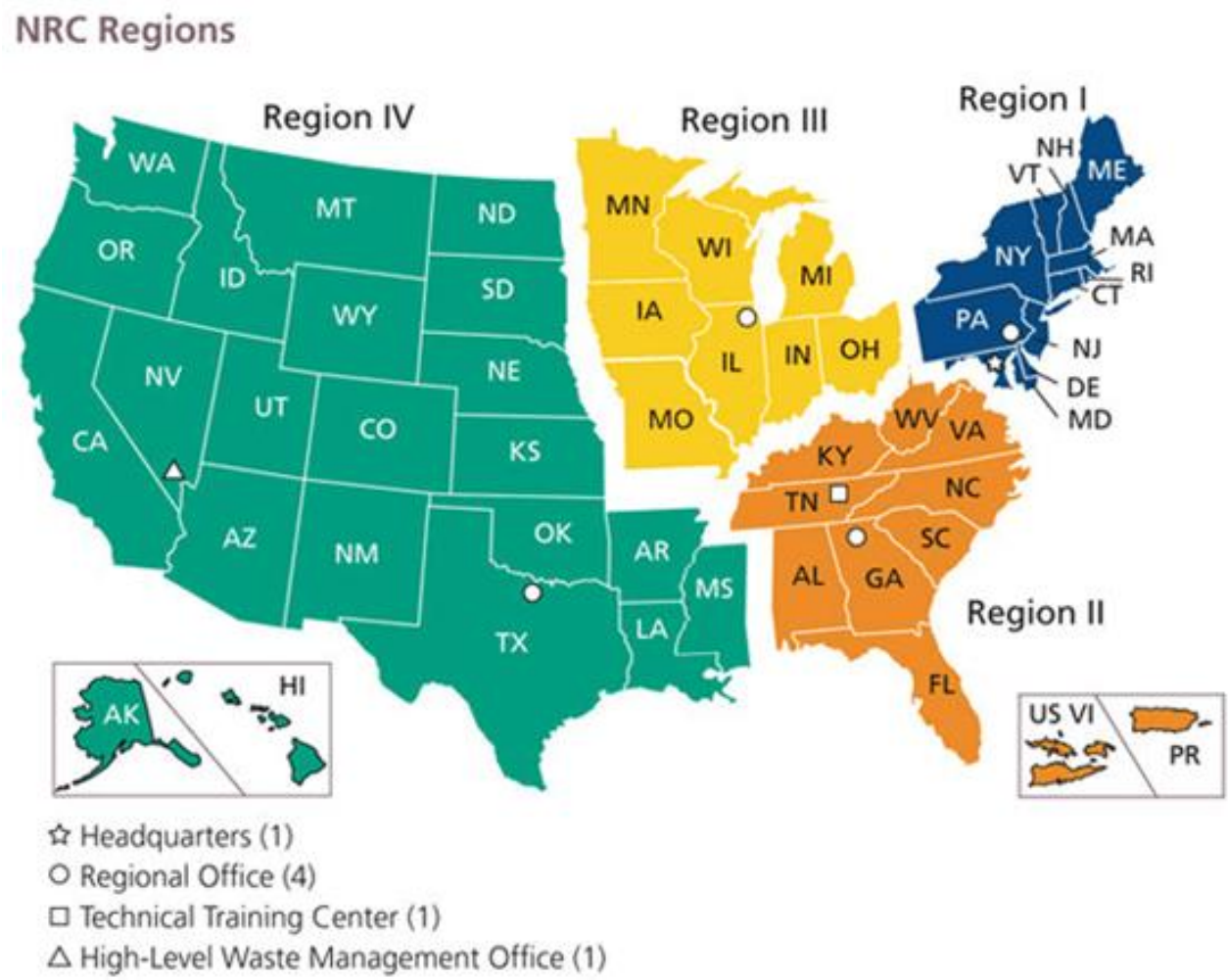

Figure E.2-3. NRC Regions

In the following paragraphs, we form an estimate of the number of transfer centers needed to repackage 3,000 MTU per year.

First, assume that one of the larger DSCs, which contain 37 assemblies (PWR) or 69 assemblies (BWR), can be fully transferred in one week at the facility. Since the distribution of fuel assembly types is approximately 43 percent PWR and 57 percent BWR, the blended average number of assemblies in a large DSC is represented as:

$$(0.43 \times 37) + (0.57 \times 69) = 55.24 \text{ Blended Average Assemblies per DSC}$$

Each one of these assemblies is assumed to contain 0.29 MTU. Therefore, each large DSC contains approximately 16 MTU, as shown in the following equation:

$$0.29 \times 55.24 = 16 \text{ MTU per DSC}$$

This is the quantity of UNF that can be transferred in one week. For 48 working weeks in a year, the amount of UNF that can be transferred from DSCs to repository STADs is represented below:

$48 \times 16 = 768$ MTU per facility, per year

Since the goal is to repackage 3,000 MTU per year, the minimum number of transfer centers required is represented as:

3,000/768 = 4 transfer centers

The number of operating reactors in each NRC region is fairly well balanced, so locating transfer centers according to NRC regions, or somewhere close to them, is potentially feasible.

The MHC concept has been developed in France for the treatment and repackaging of drum waste. Photographs of the MHC as deployed in France are shown in Figures E.2-4 and E.2-5.

Figure E.2-4. Mobile Hot Cell Deployed in the ERFB Project, Marcoule, France

Figure E.2-5. Mobile Hot Cell Deployed in the ERFB Project, Marcoule, France

For UNF transfer, the MHC is deployed over a concrete-lined pit as shown in Figure E.2-6. The MHC has rails that allow it to move from a position over the pit to a position beyond the pit, which allows casks to be lifted in and out of the pit.

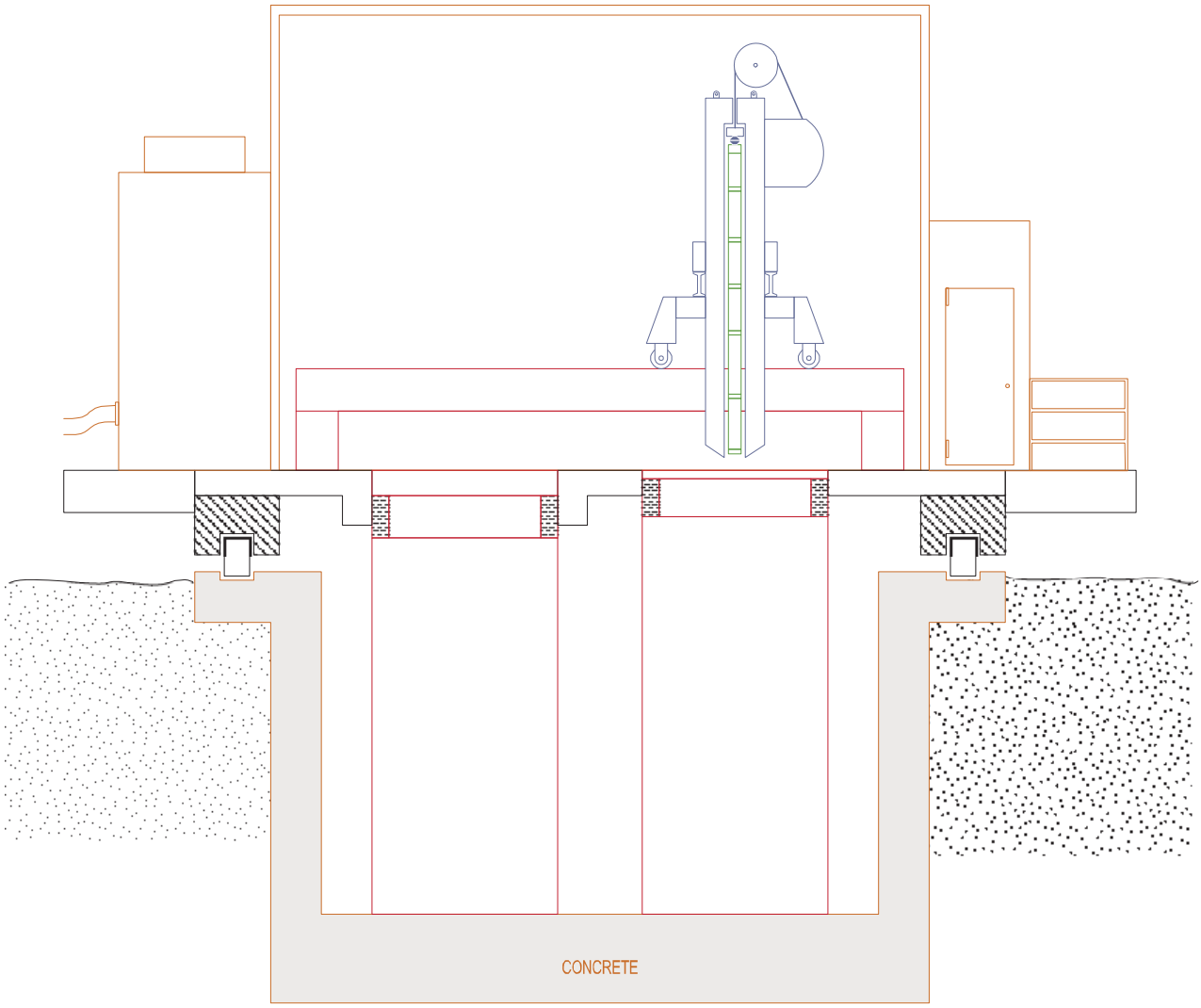

Figure E.2-6. Mobile Hot Cell Concept Configuration for UNF Transfer

An overhead crane (fixed or mobile) is necessary to place or remove the casks. The MHC then moves into position and provides a confinement space and remote controlled equipment to perform the transfer of UNF from a DSC or storage module into STADs. When the transport cask with STADs is full, the MHC shuttles to one side to permit the removal of the transport cask and its replacement with an empty cask.

This concept is suitable only for fuel in a storage or transfer cask (whether in a DSC or bare). It could also be used with a transfer cask that brings UNF directly to the facility from the utility's pool. The concept assumes that the output is a transportation cask carrying loaded STADs, which can go either to the CSF or directly to the repository, if available.

A crane places a DSC and STAD vertically in the open end of the pit. The MHC must contain, within the confinement boundary, all of the shield plugs or other components necessary to close and seal all of the STADs in the transport cask. When the two casks are in position, the MHC moves over the casks, and through holes in the floor, mates to them. (It may be advantageous to

move the casks, by means of air pallets or equivalent, into position for mating, to improve positional accuracy).

Once the mating is complete, the atmosphere inside the confinement boundary of the MHC must be replaced with an inert gas. All activities inside the MHC, beyond this point in the process, are remote controlled. The storage module can be opened, whether by removing the bolted lid or cutting the DSC closure plates. (Note these activities can be largely accomplished manually, if desired, before the MHC confinement boundary is closed. However, the final breach of the gas boundary of the fuel must be done in the inert atmosphere). Once free, the storage module shield plug may be removed and placed inside the MHC.

The transfer is performed using a shielded transfer bell and hoist. This will minimize, but not eliminate, the need for shielding of the MHC walls and ceiling. To keep the MHC as lightweight as possible, the control room should be placed at a necessary remote distance.

When the STADs are full, remote-controlled welding equipment affects the closure. Weld integrity testing, leak testing, and an external contamination check is also performed remotely. When that is complete, a transport shield plug is installed, if needed. At this point the STADs are prepared for transport, either in the open end of the pit or at grade. Used, empty DSCs are lifted out of the pit and decommissioned.

A mismatch is likely between the capacity of the DSCs and the STAD. When one of the STADs is full and needs to be changed out, the MHC de-mates from the casks, moves out of the way, awaits placement of a new STAD (full STAD or DSC), moves back over the casks, mates with them as before, and continues transferring fuel. If a heavier, shielded design of MHC is developed, a small floating inventory of fuel assemblies could be held in the MHC to reduce the number of such moves. Because three or more transportation casks are needed to accommodate the fuel in one large DSC, there would be many such moves. Due to the challenge of mating to two casks with a gas-tight boundary, this could consume a long period of time.

For these reasons, a fixed transfer facility might make more sense. The best facility would consist of two modules, one to open and unload DSCs, and another in which STADs are being loaded. In between the two modules, equipment would transfer and hold the fuel assemblies with enough float to ensure uninterrupted operations. Once a STAD is loaded, sealed, and leak tested, it would be placed in a queue for transport. The queue area needs to be shielded by thick walls without any protective atmosphere, until the next transportation cask arrives for loading. A fixed facility would also be better suited to handle any unusual fuel assembly conditions that may be encountered.

Siting on an existing nuclear utility is logical, particularly due to the fact that it is already a nuclear site and likely has a supply of skilled nuclear-qualified labor nearby. The facility would need to be sited away from the reactors and have its own infrastructure (including an entry gate and security), in order to prevent any interference with normal operations (including ISFSI operations) at the host site. Co-location may reduce the regulatory and public-acceptance hurdles as long as the loaded STADs are moved immediately to a geological repository. It would be effective to structure the facility as a separate business from which the utility would profit by receiving an adequate fee for fuel repackaged.

Public opposition is anticipated on two fronts. One is the import of UNF from other states, and the other is a concern that the transfer center could become a repository if the out-shipment rate of UNF does not match the receipt rate. These concerns are related. To address them effectively, it is clear that the repository (or CSF) must be prepared to receive the transportation casks transporting STADs at the rate that UNF is transferred. There must be no more than a nominal quantity of STADs at the transfer center at any time.

E.2.1.2 Conclusion

Loading of UNF at the reactor site is a viable alternative to loading at a CSF and it is recommended that DOE continue to pursue the design of a dry loading facility for deployment at a reactor utility site since it is almost certain that one will be required in the next 100 years at short notice as we manage the UNF inventory in the U.S.